

# NASA TECH BRIEF

## *Langley Research Center*



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### Prediction of Unsteady Aerodynamic Loadings Caused by Trailing-Edge Control-Surface Motions in Subsonic Compressible Flow

#### The problem:

It was necessary to develop a method for accurately determining the direct forces on lifting surfaces caused by the motions of trailing-edge control surfaces.

#### The solution:

A theoretical analysis and a corresponding computer program have been developed for the prediction of unsteady lifting-surface loadings caused by the motions of trailing-edge control surfaces having sealed gaps.

#### How it's done:

The final form of the downwash integral equation has been formulated by isolating the singularities from the nonsingular terms and by establishing a preferred solution process to remove and evaluate the downwash discontinuities systematically. Comparisons of theoretical and experimental pressure data have been made for several control-surface configurations. The comparisons indicate that reasonably-accurate theoretical pressure distributions and generalized forces may be obtained for a wide variety of such configurations.

The computer program developed is one of the few subsonic methods which determines direct surface loadings, using pressure terms that correctly represent the known singularity functions around the boundaries of a wing with a control surface. The pressure distributions, when applied in the integral equation relating lifting pressure and downwash, produce the identical mathematical downwash discontinuities at wing and control-surface boundaries which are contained in the kinematic distribution. A preferred solution process is developed by subtracting the discontinuous mathematical downwash distribution from the discontinuous kinematic

distribution, resulting in a smooth downwash distribution for which standard lifting-surface solutions by downwash collocation can be applied. The resulting loadings are relatively insensitive to the locations and numbers of control points used in the analysis.

The program is an extension of the analytical methods currently available, and it provides the numerical prediction of the unsteady loadings caused by control-surface motions. The following eight capabilities are available:

1. Wing leading and trailing edges can each be made up of from one to nine straight-line segments, with no segment offset chordwise. (Collocation points should not be located in any chordline passing through such breaks.)
2. Up to four controls per half span.
3. Deflection-mode data for up to 110 points on the half span are interpolated by a surface spline to up to 72 downwash collocation points (on up to 9 span stations per half span and up to 8 points per span station) for up to 19 deflection modes.
4. Parallel results can be obtained for two types of gust distribution: continuous sine-wave and oscillatory aircraft vertical translation.
5. Spanwise symmetry and antisymmetry.
6. Chordwise variation of  $V$  (free-stream velocity) in the downwash collocation value  $w/V$  (kinematic angle of attack or nondimensional normal wash) due to airfoil thickness distribution.
7. Optional output of generalized forces, section generalized forces, and chordwise distributions of pressure.
8. Optional saving of input data and intermediate output data on tape files for economy of subsequent use.

(continued overleaf)

**Notes:**

1. This program was written in FORTRAN IV (99%) and COMPASS (01%) for the CDC 6000-series computer.
2. Inquiries concerning this program should be directed to:

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under contract to  
Langley Research Center  
(LAR-11175)